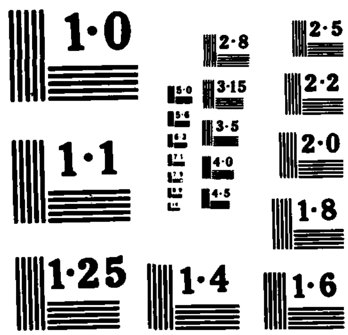
AD-A155 563 THIRTY YEARS OF TROPOSCATTER COMMUNICATIONS(U) FOREIGN TECHNOLOGY DIV WRIGHT-PATTERSON AFB OH Z LUO 07 MAY 85 FTD-ID(RS)T-0237-85 1/1

UNCLASSIFIED F/G 17/2.1 NL


1·0
2·8
2·5
3·15
2·2
3·5
1·1
2·0
4·0
4·5
1·8
1·25
1·4
1·6

FTD-ID(RS)T-0237-85

FOREIGN TECHNOLOGY DIVISION

THIRTY YEARS OF TROPOSCATTER COMMUNICATIONS

by

Luo Zhengbin

EDITED TRANSLATION

FTD-ID(RS)T-0237-85 7 May 1985

MICROFICHE NR: FTD-85-C-000258

THIRTY YEARS OF TROPOSCATTER COMMUNICATIONS

By: Luo Zhengbin

English pages: 11

Source: Dianzi Xuebao, Vol. 11, Nr. 4, 1983, pp. 43-47

Country of origin: China
Translated by: FLS, INC
F33657-85-D-2079
Requester: FTD/TQCT
Approved for public release; distribution unlimited.

GRAPHICS DISCLAIMER

All figures, graphics, tables, equations, etc. merged into this translation were extracted from the best quality copy available.

THIRTY YEARS OF TROPOSCATTER COMMUNICATIONS*

Luo Zhengbin

Shijiazhuang Communications Laboratory

This paper reviews the troposcatter communication advances for the past thirty years or so, summarizes China's achievements in this field, and discusses the possible trends for future developments.

I. Development Outside of China

From the late 1940's, there was a great increase in the interest in beyond the horizon troposcatter communications, and large amounts of experimental and theoretical studies have been made. In the early fifties, the knowledge of the characteristics and regularities in beyond the horizon troposcatter communication advanced a great deal. In 1955, ITT Corporation of the United States established the world's first troposcatter communication-link between Nutley, N.Y. and Southampton, Canada, marking the beginning period of its application. From that time on, it became a reliable means of communication and was improved continuously for the next thirty years. During this thirty-year period, its development can be divided into three stages.

*World Communication Year special topic

The mid-fifties to mid-sixties marked the first stage: rapid development and application of analog troposcatter communication. This method could provide a large single communication distance, and a large communication capacity (240 channels - 300 analog voice channels). It could also be used to establish communication networks rapidly and economically in sparsely populated, geographically complicated and hard-to-reach areas. As a result, it attracted a lot of interest from various countries. In the short period of ten years, the communication links established by Western countries reached 130 thousand kilometers, and the Soviet Union established scatter radio wave links with a total length of over 100 thousand kilometers between fixed stations. In addition to the fixed stations, the Western countries and the Soviet Union have manufactured and maintained some mobile units.

During this time, the US, UK, Japan, France and the Soviet Union quickly established standards and systematic production for troposcatter communication facilities (both fixed and mobile stations). The working frequency band of these units varied from 350 MHz to 5000 MHz; the power of transmission from 1 Watt - 100 kilowatts; the diameter of the antenna from 2.4 - 40 meters; the capacity from 4 - 300 channels; the noise temperature of the low noise amplifier may reach $70^{o}K$ - $150^{o}K$; and the units used the anti-fading diversity recaption technology and low threshold demodulation technique.

At the same time, a large amount of experimental and theoretical studies on troposcatter propagation was going on to improve engineering design.

The mid-sixties to the mid-seventies represented the second stage. The growth of troposcatter communication links increased at a slower rate. Even though there were thousands of kilometers of scatter communication channels being put in service every year, there were some main channels replaced by short-range (within the visual horizon/distance) radio wave relay stations and satellite

telecommunication. This was due to the scatter communication capacity no longer satisfying the communication demand. In addition, the Western countries and the Soviet Union completed most of the scatter communication network. The more important factor is that the development of satellite communications was rapid, and many countries turned their attention to establishing satellite communications. As both research and later application would indicate, however, neither satellite communication nor microwave short-range communication could completely replace troposcatter communication.

Regardless of the slower rate of troposcatter application, the development of its technology did not stop. On the one hand, analog communication facilities were being improved using the integrated circuit and making it smaller, and on the other hand, a great research effort was made in digital troposcatter communication. After studies of more than ten different digital modulation/demodulation techniques, more satisfying data and more efficient code and demodulation techniques were found. The theoretical and experimental studies of this type of system were finished in the mid-seventies. Research using iterative code to improve its capability and to enlarge its communication capacity also made some impact. A transmitting speed of approximately 1×10^{12} bits/sec of digital scatter communications equipment was put in use.

From the mid-seventies on marked the third stage. From then on, not only was a lot of attention given to troposcatter communication by the military, but civilian communication also established a large number of channels. First of all, this was due to the fact that troposcatter communication cannot be replaced by satellite communication and microwave short-range relays (repeaters). Foreign specialists feel that, in a nuclear war, it can withstand more destruction than satellite or microwave short-range repeater communication, and will be one of the few remaining communication methods that the military can use. In military use,

mobile units are even more useful. To increase military mobility, it is necessary to reduce the amount of equipment and technical support personnel. The short-range radio wave relay stations will eventually be replaced by improved radio-relay/scatter stations.

From the commercial standpoint, troposcatter communication has the characteristic of the long-range (beyond the horizon) relay, and fills the void between satellite and short-range microwave repeater systems. It can be used economically in sparsely populated desert areas, marsh lands, high altitude and frigid regions, and is suitable for developing countries. Since the seventies, some developing countries have already used it to establish internal communication stations. In addition, since the development of off-shore oil drilling, it becomes a strong competitor in communications between the land stations and oil-drilling platforms. The distance between off-shore oil fields and the shore is usually beyond the short-range and within 300 kilometers. At present, the possible methods of multi-channel communications are undersea cable, troposcatter, and satellite communications. Undersea cable not only requires expensive installation, but also may be damaged by working ships in the area, and as a result, is rarely used. Comparison between satellite and troposcatter communications, according to the European North Sea Oil Field Communication Cost Analysis shows: the cost per voice channel for leasing the former is 3200 British Pounds and for the latter 1690 British Pounds, nearly twice as much. Besides, troposcatter communication can provide spare channels, and, therefore, has higher reliability. As a result, troposcatter was used as the main source of communication at the British North Sea Oil Field.

In conclusion, in the late seventies, research for a new generation of digital and analog troposcatter communication equipment has been successful in the US, UK, and the Soviet Union, and it has made wide applications. Tables 1 - 3 reflect the latest standards and technical capabilities for the new generation of

scatter communication equipment. Some of the new technologies are: highly efficient and long-lasting Klystron, evaporation-cooled radio frequency power amplifier, programmable frequency synthesizer, low noise amplifier cooled by semiconductor, the signal amplifying stage of the micro integrated circuit, micro circuit parts and LSI, self-adjusting distortion, decisive feedback self-adapting technique, correction encoding/decoding technique, scatter station remote control technique, long focus dual feedback antennas; high efficiency feedback speaker; angle diversity technique, and installation with accurate and fast alignment, etc.

Table 1

Major Characteristics of
English Marconi Mobile-type/Troposcatter/Communication System
Items and Their Characteristic Values

---

1. Working frequency: 4.4~5.0 GHz
2. Frequency separation: 100 kHz
3. Frequency stability: $1x10^{-8}$/day, $1x10^{-7}$/month
4. Distance of single transmission: 50~250 km
5. Receiver noise factor: 4.5 dB
6. Diversity method: angle, space or frequency diversity
7. Diversity depth: 2 or 4 times
8. Summation method: use the highest ratio
9. Transmitting power: 1 kW (air cooled)
10. Antenna diameter: 4.5 m
11. Digital:

    baud: 256, 512, 1024 or 2048 kb/sec

    channel baud: 16 kb/s $P_{e\ max} \leqslant 10^{-3}$

    service channel: 2 channels (16 kb/s)

    monitor channel: 16 kb/s

    modem: 4PSK [Coherent scattering demodulation]

    encoding: separation correction code

12. Analog type

voice capacity: 12~300 channels

service channel: 300~2700 kHz

monitor channel: 3~12 kHz

mo/dem tech: FM/PPL [expansion unknown] lower threshold

threshold noise ratio: 6 dB

13. Environmental conditions

Operating temperature: -30~+52°C

relative humidity: 40°C, 95%

height: 3600 m

14. Installation time: 3 man-hours

Major Characteristics of
Table 2 American AN/TRC-170 Digital Troposcatter Communication System

Model Type / Items		V-1	V-2	V-3
Working Frequency Frequency separation Reference clock		4.5~5.0 GHz 100 kHz Rb		
Receiver noise factor		3.0 dB (semi-conductor GaAs FET [Field Effect Transistor] amplifier)		
Frequency band occupation		3.5 or 7.0 MHz		
Transmission Baud		128, 256, 512, 1024, 1356 or 2048 kb/s		
No. of voice Channel	32 kb/s	7 15 30 45 60		
	16 kb/s	7 15 30 60 90 120		
Single transm. distance		320 km	240 km	160 km
No. transmitter & power		2/6.6kW	2/1.85 kW	1/2kW, 0.65kW
Diversity and depth method		4 amplitude/ frequency	4 amplitude/ frequency	2 amplitude
No. of antennae & diameter		2 prs, 15'	2 prs/9.5'	2 prs/9.5'
antenna gain		44.5 dB	40.5 dB	40.5 dB
total weight		12000 lb	6000 lb	5000 lb
Interstation service channel working temperature Height		US Military 32/16/ kb/s per voice channel service: 16kb/s; commanding:4x2 kb/s -46°C ~ +52°C, suitable for tropical use 3000 m		
manufacturer		Raytheon Co., Equipment Division		

Table 3

Major Characteristics of AMTA, AMTD, AMTW Series Scatter Communication System

Items	AMTA Series	AMTD Series	AMTW Series
Operating Frequency	0.75~0.96 GHz	1.7~2.7 GHz	4.4~5.0 GHz
Frequency stability	$\pm 1 \times 10^{-10}$/day		
Frequency separation	5000 kHz		
Receiver noise factor	4.0~3.5 dB	4.5~4.0 dB	
Receiver threshold		$P_C = 10^{-6}C$ $E_b/N_o = 15$ dB	
Diversity method	space, angle polarization, frequency, or their combinations	space, angle, frequency diversity or their combinations	
Channel bandwidth	any bandwidth up to a max. of 10 MHz	twice the data speed	
Modulation method	FDM-FM	TDM -4PSK	TDM-4PSK
Demodulation method	lower threshold demodulation	mating filter digital demod.	self-adjusting feedback equalizing coherent scattering demodulation
Service channel	0.3~12kHz	192 kb/s	192 kb/s
Transmitter power	1.10kW	1.10kW	2.10kW
Working temperature	-18~+55°C	0~+50°C	0~+50°C
Rel. humidity	95%	90% at 25°C	90% at 25°C
Height	4500 m		
Manufacturer	Aydin (USA)		Aydin, GTE

Since a troposcatter communications facility satisfies the requirements of high accuracy, reduced size and requires no attending personnel, the communication capacity for digital-type equipment has reached or has even surpassed that of the analog type, and the mobile stations coexist with the radio wave line-of-sight communication. This provides a great future for the

application of troposcatter communication in both military and civilian areas.

II. Development in China

Since the late fifties, we began the measurements of troposcatter transmission and research in this area, and gathered a large volume of data in northern and eastern China. According to these data, our Wave Communication Research Department has established a system for scatter transmission loss and circuit-design computation.

Our research in troposcatter communication started in the early sixties. Due to the limitation of instrument quality, we first made a vacuum tube FM analog frequency transmitter in the meter-range with a capacity of 12 channels, followed by one in the centimeter-range with 60 channels. Since the late sixties, we have also engaged in the developmemt work on digital troposcatter communication equipment. In the early eighties, we successfully made long-range stationary transmitters and short-range mobile-type transmitters, both of which are the relatively advanced digital type. Both use in-band frequency diversity, highly efficient time-frequency-phase modulated signals; and coherent scattering, and difference coherent scattering, respectively; time-sharing multi-user discrete convolution coding and decoding techniques to send telegram and data signals. With the exception of power amplifier devices, transistor and solid state integrated circuits were used. This equipment, with standard and automated design, has a high flexibility and can be easily and widely adapted for different requirements. They are highly capable and are easy to use. In 1982, a foreign specialist in the area visited our facility and commented that whatever standard their products can reach, we can reach them also if we can get the quality and technical standards and electronic elements together with production facilities and quality control. This agrees with our own estimation after visiting other countries.

Our vast geographic area is complex. The long coastline with many islands, sparsely populated desert and frigid northwestern regions, and the mountainous terrain in the southeast are all suitable for using troposcatter communication. Since the late sixties, our industry has gradually established some regional troposcatter communication links. Its superiority has been established. However, regardless of its potential, compared to foreign applications and usage, it is still in the beginning stages in our country. The fields where we need it are wide: communications in off-shore oil drilling, electricity distribution control, oil and gas transportation control, newly operated mines, as well as military communication. Following the constant development of the Four-Modernization Plan, we need more research and development in troposcatter communication facilities and to establish even more communication links.

III. Brief Outlook of Future Development

Combining the opinions of many specialists, the future development of troposcatter communication will lie in the direction of:

1) During the transition from analog to digital type of communication, using newly developed digital troposcatter transmitting equipment to gradually replace the analog scatter communication channels.

2) Finding the best communication signal and self-adapting communication method, in order to increase channel frequency and baud efficiency and develop its utmost potential.

3) Using the best combination of modulation and coding techniques to study the low capacity mobile station with only one pair of antennas and one set of transmitters in order to reduce the cost and increase its mobility.

4) Allowing the troposcatter to gradually replace the existing short-range radio wave relay stations.

5) Improving the components, making them smaller. Using micro components, semiconductor frequency power amplifier reaching into the kilowatt range and mountable on antennas. This would greatly reduce the volume and the weight of the equipment.

6) Increasing its anti-distortion ability and its ease of being hidden. For example: use a self-adjusting transmitting power system; decrease constant transmitting power; use small angle with definite orientation, automatically changing its working requirements; use pre-determined signals transmitted over a short period of time; develop special antenna which can be easily hidden.

7) Develop remote control troposcatter communication; for example, use troposcatter communication equipment to remote control some automated set-ups.

8) Increase its civilian use, especially in the area of communication for off-shore oil platforms, distribution of electricity, transportation of oil and gas, mines, and radio and television transmissions.

IV. Conclusion

In developing the troposcatter resource, we have accomplished a great deal in spite of our late start. This is exemplified by the use of new digital troposcatter communication. However, to broaden the application is not an easy task. Just like other electronic products, only wide usage among various departments can then speed up its development, thereby reducing its cost. More importantly, it can then be improved upon and its economical benefit be realized. Therefore, each area of Research, Development, Production, Users and Educators must cooperate to the

fullest extent, since each is an individual link in a long chain for the Modernization Plan.

END

FILMED

7-85

DTIC